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MAR 77 R W DRISKO, L K SCHWAB, T B O'NEILL

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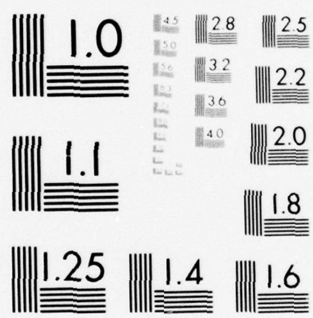


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# Technical Note

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**TN no. N-1474**

**title:** UNDERWATER APPLICABLE ANTIFOULING PAINTS - INITIAL ONE YEAR STUDY

**author:** R. W. Drisko, L. K. Schwab, and T. B. O'Neill

**date:** March 1977



**sponsor:** Director of Navy Laboratories

**program nos:** ZF61.512.001.069



**CIVIL ENGINEERING LABORATORY**

NAVAL CONSTRUCTION BATTALION CENTER
Port Hueneme, California 93043

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Epoxy coatings with antifouling properties were field-tested to determine (1) the minimum tin content necessary to retard marine biological fouling and (2) whether a leaching agent such as rosin was necessary to permit toxicant release at a rate sufficient to retard fouling. Only paint with 6% tin compared favorably in fouling resistance with the copper-based antifouling paint used as a standard. It may be that fouling resistance will not be greatly affected if the tin content is reduced below 6% and rosin is incorporated into the


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formulation to accelerate the release of tin.

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CONTENTS

## INTRODUCTION

The Civil Engineering Laboratory (CEL) has developed protective coatings that are applied underwater by brush or roller to clean, steel surfaces. Cooperative field testing* of these epoxy coatings with the Naval Coastal Systems Laboratory (NCSL), Panama City, Florida, indicated that such materials are of great potential value** to the Navy and that introduction of antifouling properties into them would also be very useful. Thus, a study was initiated to determine the effectiveness of the CEL coatings as antifouling paints when organotin biocides were incorporated into them. The study had two objectives. The first was to determine the minimum tin content necessary to retard marine biological fouling, and the second was to determine if a leaching agent such as rosin was necessary to permit toxicant release at a rate sufficient to retard fouling. It should be noted that such action might reduce the corrosion-inhibiting properties of the paint by making the protective film more permeable to seawater and thus require separate corrosion-inhibiting undercoats.

## MATERIALS TESTED

The initial study utilized paint formulations available from the previous cooperative tests conducted with NCSL. Relatively quick answers were sought to the questions:

1. Is there a minimum amount of tin required to control fouling?
2. Is it necessary to add a leaching agent to underwater applicable antifouling paints to make them effective?

The effect of adding a leaching agent (rosin) is being investigated in a later study.

Ten different paints were used in the initial study. Formula 1 was identical to that of CEL Formulation 101-2 previously tested at NCSL and described in Table 1. It contained no tin and so served as a control to establish the rate of fouling on painted surfaces without a biocide. Formulas 2, 3, and 4 were variations with different added amounts of

*Civil Engineering Laboratory. Technical Note N-1426: Underwater-applied coatings for steel structures, by R. W. Drisko. Port Hueneme, CA, Mar 1976.

**It is estimated by Navy scientists that 25% of Navy fuel costs are linked to hull fouling. A 10% saving in fuel costs is estimated, resulting in an $8 million saving in fuel costs based on 1974 prices.

organotin (either bis(tri-n-butyltin) oxide or its reaction product with the fatty acids of linseed oil, or both). Formula 5 (see Table 1) was identical to Formulation 101-19 of the CEL-NCSL tests, and Formulas 6, 7, and 8 were variations of it with different amounts of organotin biocide added. Formula 9 was a hastily prepared and hand-mixed formulation without the heavy corrosion-inhibitive pigment (lead silica chromate pigment) of Table 1 in order to obtain a greater weight of tin. Formula 10 was MIL-P-15931B vinyl red, copper-based, antifouling paint (Formula 121/63) and was chosen as a comparison standard to see how closely its resistance to fouling could be approached.

Analyses of Formulas 2 through 9 for percentage of tin were made using a Beckman Atomic Absorption Spectrophotometer 485. Results of the analyses are listed in each of the ratings (Tables 2 through 15) for quick reference.

## PANEL PREPARATION

Three sets of 10 panels were prepared for field exposure using the 10 test paints. Steel panels 12 x 6 x 1/8 inches were sandblasted (Figure 1) to white metal (Steel Structure Painting Council Surface Preparation No. 5) and sprayed with one coat of CEL Underwater-Applicable paint.* They were later brushed with an additional coat of this material to give a total dry film thickness of 5-1/2 mils. Panels were edge-dipped in this formulation, tagged for identification and soaked in seawater for 3 days prior to application underwater of the test paints. A small quantity of carbon black (0.1% by weight) was added to Formulas 1 through 9 in order to obtain a different color from Formula 101 and insure complete coverage of this material over the coating previously applied to the panels. A special wooden holder (Figure 2) was used to simplify application of the paints under water to both sides of the panels (Figure 3). The panels were stacked in a special holder and allowed to cure under water for 1 week before exposure in Port Hueneme harbor. Formula 10 (MIL-P-15931) was applied by conventional brushing and allowed to air dry 1 week before immersion.

## PANEL EXPOSURE AND RATING

One set of 10 coated panels was randomly selected and sent to Panama City, Florida, for exposure by NCSL personnel. The remaining 20 panels were placed in test racks (see Figures 4 and 5) and exposed in Port Hueneme Harbor. These latter panels were rated monthly for type and extent of fouling.

*Identical to Formula 101-19 of Table 1 without the organotin biocide.

After the second and third months of exposure at Port Hueneme the surface of each panel was streaked with a sterile cotton swab which was then asceptically restreaked on seawater bacterial and fungal media. The microorganisms were later grown and identified in the laboratory. Their identification is presented in Tables 2 and 3.

After 1 month of exposure at Port Hueneme only a primary film (slime) was noted on any of the panels. Monthly fouling ratings from the second to twelfth month are listed in Tables 4 through 14. The fouling organisms were counted where possible until prevented by excessive growth.

After 10 months of exposure at Panama City, the test panels were rated by CEL personnel.

## FINDINGS AND CONCLUSIONS

From Tables 2 and 3, it was found that numerous microorganisms were present in the primary films on the test panels at Port Hueneme. These included bacteria, yeasts, algae, filamentous fungi, and diatoms. Most species occurred sporadically, but two bacteria (*Achromobacter* and *Pseudomonas*) were present on all panels after 2 and after 3 months, and some others occurred on most of the panels. No major differences were found on panels with and without biocide for retarding fouling, and no specific microfouling requirement for macrofouling (i.e., no dependency of microfouling organisms on previous primary film) was apparent.

From Tables 4 through 14, several findings concerning macrofouling at Port Hueneme were apparent. Microfouling occurred on all panels after 1 month and macrofouling (in the form of hydroids) was found after 2 months on both control panels (without biocide) and on four panels with organotin biocide. Next in order of appearance were barnacles (3 months), bryozoa (3 months), algae (3 months), tunicates (3 months), tube worms (5 months), mussels (6 months), and sponges (8 months). The control panels (Figure 6) were always more heavily fouled than those containing biocide (Figure 7). The only underwater-applied paint that approached the standard copper-based paint for antifouling properties was the one containing 6% tin, and it performed quite well in this regard.

At Panama City each panel was rated by CEL personnel after 10 months; this rating is shown in Table 15. As can be seen from this table and from Figure 8, barnacles predominated over other fouling organisms, and, in comparison to Port Hueneme, relatively few other types of fouling organisms were present. With one exception (Formula 5) the results were consistent with the Port Hueneme results in that only Formula 9 (with 6% tin) compared favorably with the copper-based antifouling paint (Formula 10). The absence of macrofouling on the panel coated with Formula 5 may be due to a localized anaerobic condition that produced a black film on it.

In tests conducted 16 months earlier at Panama City, eleven 2-foot-square steel panels had been coated under water by divers. Four were painted with Formula 1 and seven with Formula 5. Table 16 and Figures 9 and 10 show that the paint with no biocide (Formula 1) had much heavier fouling than the paint with 0.9% tin (Formula 5) and had much growth of oysters. Apparently oyster fouling on painted panels is initiated after 10 and before 16 months at Panama City in the fouling progession there.

From the studies at both locations it was concluded that addition of as little as 0.9% tin to the paint formulations reduced fouling to an easily detectable extent. Only the paint with 6% tin, however, compared favorably in fouling resistance with the copper-based antifouling paint (MIL-P-15931) used as a standard. It may be that fouling resistance will not be greatly affected if the tin content is reduced below 6% and rosin is incorporated into the formulation to accelerate the release of tin. This will be determined in a second study conducted by CEL.

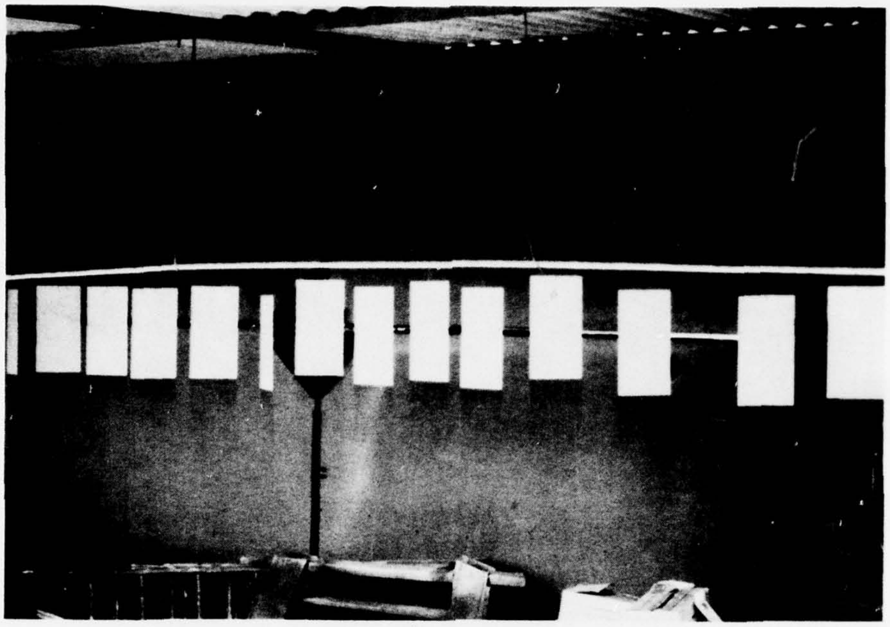


Figure 1. Sandblasted steel panels ready for painting.

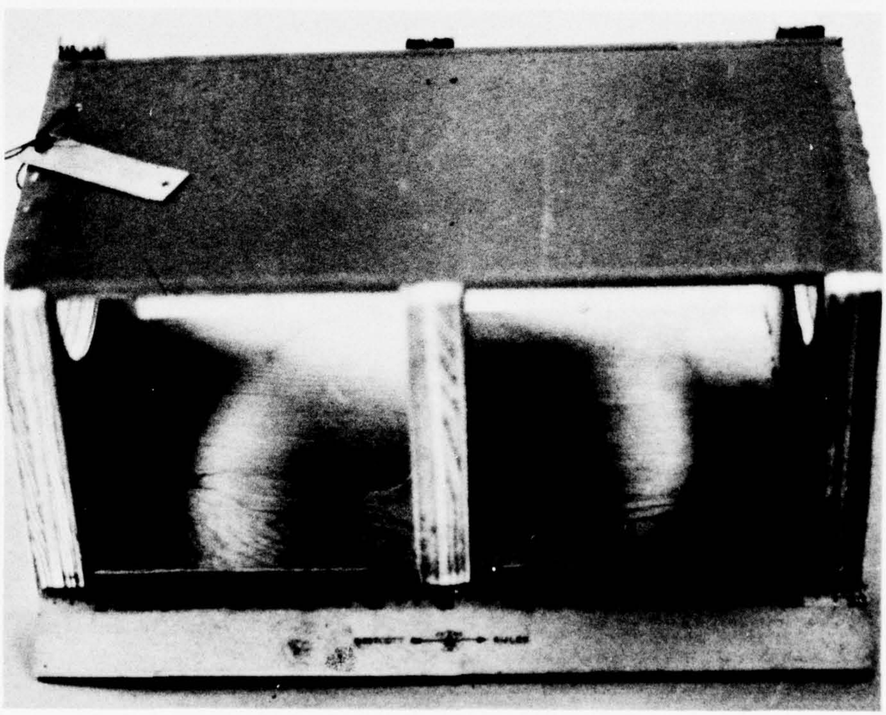


Figure 2. Test panel in rack used for painting under water.

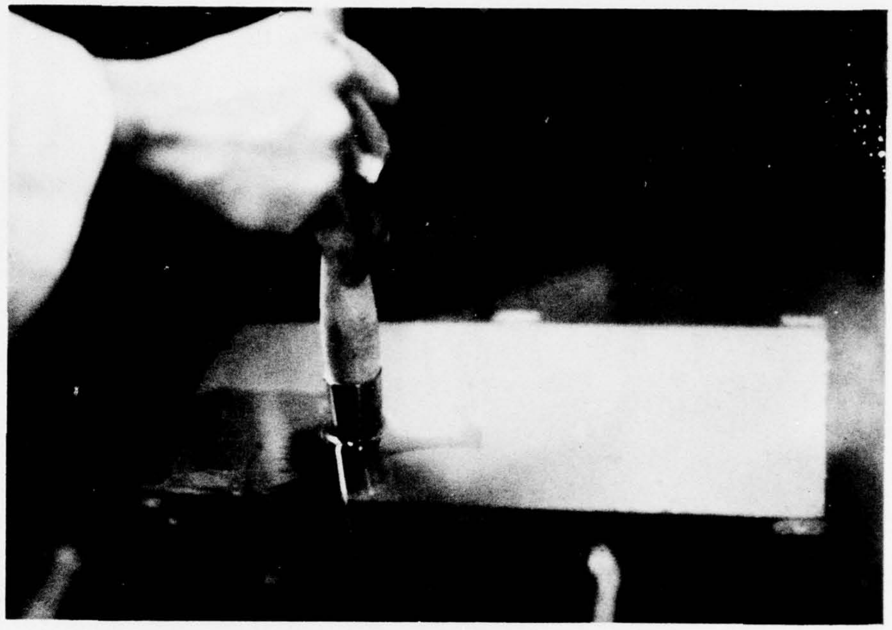


Figure 3. Underwater application of test paints.

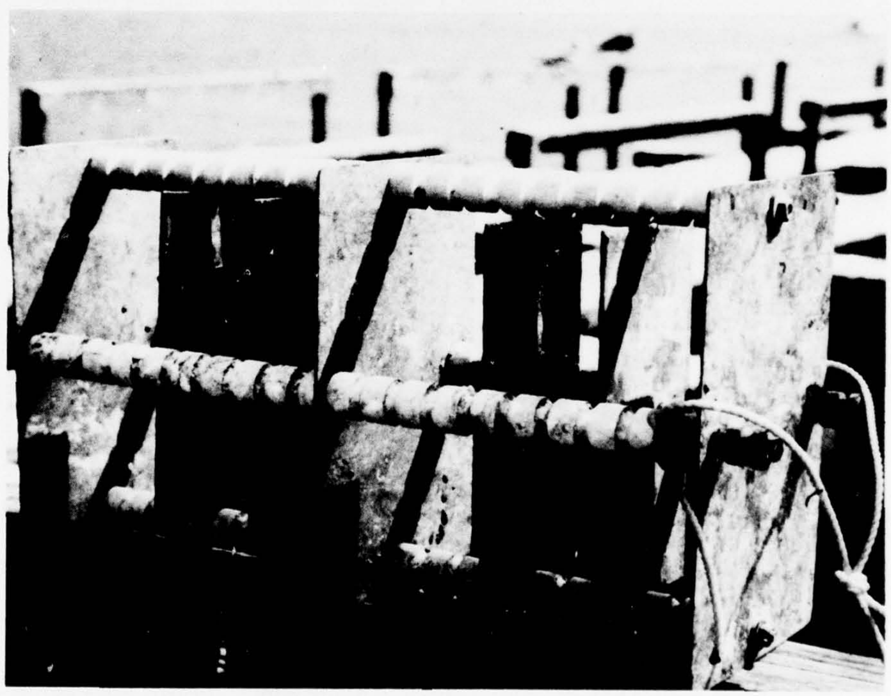


Figure 4. Test panels in exposure rack.

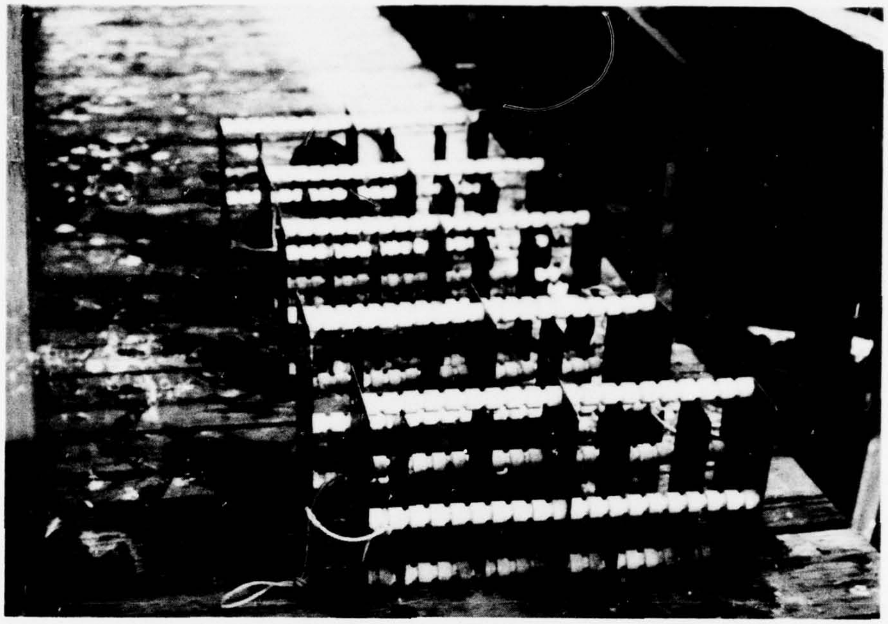


Figure 5. Exposure racks ready for immersion.

Figure 6. Control panel after 6 months.

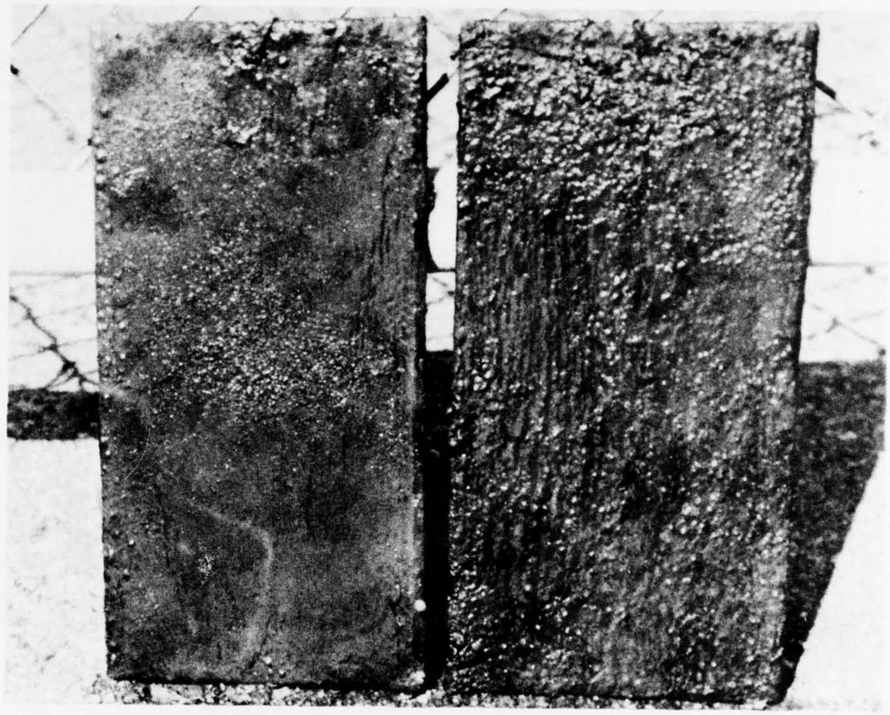


Figure 7. Panel with 6% tin after 12 months.

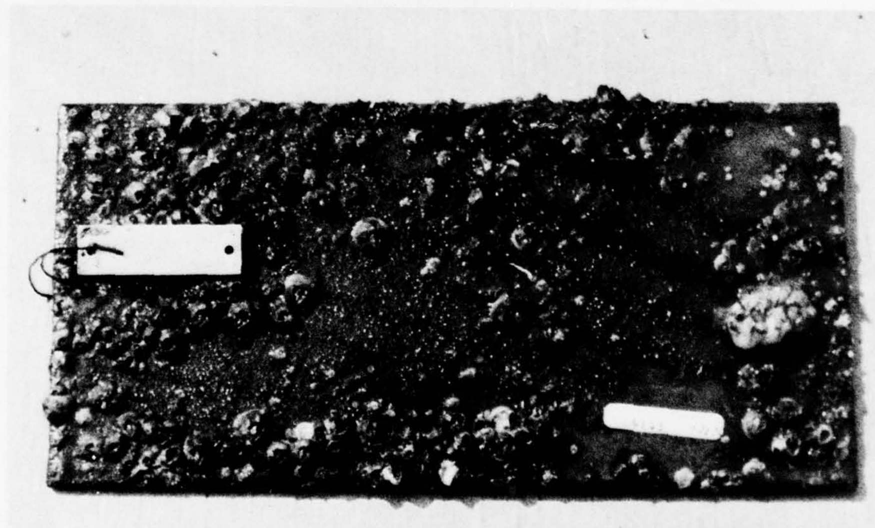


Figure 8. Control panel at Panama City after 10 months.

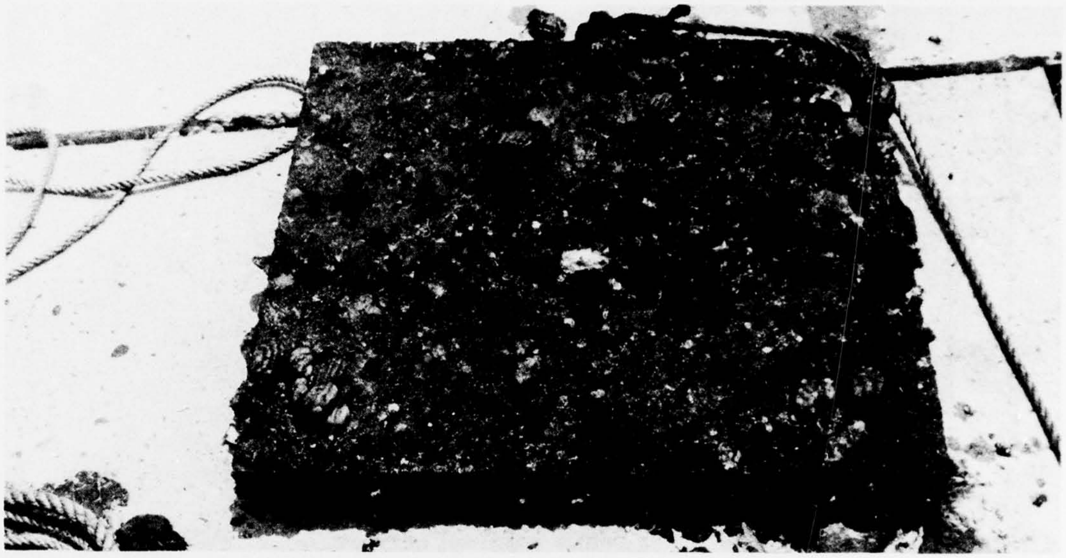
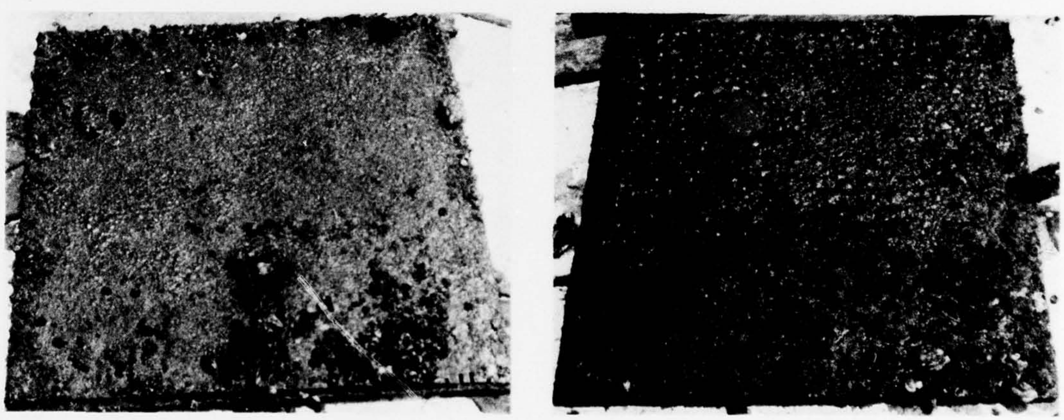


Figure 9. Panel without biocide at Panama City after 16 months.



(a) Light fouling.

(b) Moderate fouling.

Figure 10. Two panels with 0.9% tin at Panama City after 16 months.

Table 1. Formula of Underwater-Applicable Paints

| Formula | Part A | | Part B | |
|---|---|---|---|---|
| | Component | By Weight | Component | By Weight |
| 101-2 | Epon 828[a] | 42 | Epicure 8701[b] | 8.7 |
| | Lead Silica Chromate | 38 | Epicure 874[b] | 1.4 |
| | Blown Fish Oil, Z-7-1/2 | 17 | Epon 828 | 1.9 |
| | Butyl Cellosolve | 3 | Anacamine 10[c] | 6.0 |
| | | 100 | | 18.0 |
| 101-19 | Epon 828 | 42 | Epicure 8701 | 11.6 |
| | Lead Silica Chromate | 38 | Epicure 874 | 1.9 |
| | Blown Fish Oil, Z-7-1/2 | 17 | Epon 828 | 2.5 |
| | Butyl Cellosolve | 3 | Tin Biocide[d] | 5.0 |
| | | 100 | | 21.0 |

[a]Trade name of Shell Chemical Company.
[b]Trade name of Celanese Resins.
[c]Trade name of Anchor Chemical Company.
[d]Reaction product of bis(tri-n-butyltin) oxide and the fatty acids from linseed oil (added to Part B immediately before mixing with Part A).

Table 2. Genera and Relative Abundance of Microorganisms o

| Paint Formula | Tin (%) | Achromobacter (B) | Alternaria (F)[b] | Amphisphaeria (F) | Aspergillus (F)[b] | Candida (Y) | Cephalosporium (F) | Chaetonium (F) | Cirrenalia (F) | Cladosporium (F) | Cocconeis (D) | Corollospora (F) | Cryptococcus (Y) | Culcitalna (F) | Ectocarpus (A) | Enteromorpha (A) | Flavobacterium (B) | Grammatophora (D) | Helicoma (F) | Leptosphaeria (F) | Lulworthia (F) | Melosira (D) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | S | S | O | O | S | S | O | S | O | S | O | S | S | S | S | S | O | S | O | S | S |
| 1 | 0.0 | S | S | O | S | S | O | O | O | O | O | O | O | O | S | O | S | O | O | O | O | O |
| 2 | 1.0 | S | S | O | O | S | O | O | S | O | O | O | O | S | O | S | S | O | O | O | O | O |
| 2 | 1.0 | S | O | O | O | S | O | O | O | O | O | O | S | O | O | S | O | O | O | O | O | O |
| 3 | 1.8 | S | S | O | S | S | O | O | S | S | O | O | S | S | S | S | S | O | O | O | S | S |
| 3 | 1.8 | S | S | O | O | S | O | O | O | O | S | O | S | S | O | O | S | O | O | O | O | O |
| 4 | 2.3 | S | S | O | O | S | O | O | O | O | S | O | S | O | S | O | S | S | O | O | S | O |
| 4 | 2.3 | S | S | O | S | S | O | O | S | S | S | O | S | S | S | S | S | O | S | O | S | S |
| 5 | 0.9 | S | S | O | S | S | O | O | O | O | O | O | S | O | S | O | S | O | O | O | S | O |
| 5 | 0.9 | S | S | O | O | O | O | O | O | O | S | O | S | O | O | O | S | S | O | O | S | O |
| 6 | 1.8 | S | S | S | S | S | O | O | O | O | S | O | S | O | S | S | S | S | S | S | S | S |
| 6 | 1.8 | S | S | O | O | S | O | O | S | S | O | O | M | S | O | O | M | S | O | O | S | O |
| 7 | 2.6 | S | S | O | S | S | O | S | S | O | O | O | S | S | O | O | O | S | O | O | O | S |
| 7 | 2.6 | S | S | O | S | S | O | O | O | S | O | O | S | S | M | S | S | O | O | O | S | O |
| 8 | 3.1 | S | O | O | S | O | O | O | S | O | S | O | S | S | O | S | S | O | S | O | S | S |
| 8 | 3.1 | S | S | S | S | S | O | O | S | S | O | S | S | S | S | S | S | S | S | O | O | O |
| 9 | 6.0 | S | S | O | S | S | O | O | S | S | S | O | S | O | S | S | O | O | O | O | S | S |
| 9 | 6.0 | S | S | O | S | S | S | O | S | O | S | O | S | O | O | O | M | S | O | O | S | O |
| 10 | 0.0 | S | S | O | S | S | O | O | O | S | S | O | S | S | O | O | O | O | S | O | S | O |
| 10 | 0.0 | S | S | O | S | S | O | O | O | O | S | O | S | O | S | O | S | S | O | O | S | O |

[a]Abbreviations for type and amount of growth: A = Filamentous alga; B = Bacterium; D = Diatom; F = Filamentous fungi; Y = Yeast; G = Abundant growth; M = Moderate growth; S = Sparse; O = No growth.

[b]Nonmarine specie present as transient.

ble 2. Genera and Relative Abundance of Microorganisms on Test Panels After 2 Months[a]

| Cryptococcus (Y) | Culcitalna (F) | Ectocarpus (A) | Enteromorpha (A) | Flavobacterium (B) | Grammatophora (D) | Helicoma (F) | Leptosphaeria (F) | Lulworthia (F) | Melosira (D) | Metschnikowiella (Y) | Nitzschia (D) | Penicillium (F)[b] | Polysiphonia (A) | Pseudomonas (B) | Rhizopus (F)[b] | Rhodotorula (Y) | Sarcina (B) | Striatella (D) | Streptomyces (B) | Torpedospora (F) | Torulopsis (Y) | Trichoderma (F) | Zaleriom (F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | S | S | S | S | O | S | O | S | S | S | O | S | S | G | S | O | O | O | O | S | S | O | S |
| O | O | S | O | S | O | O | O | O | O | S | O | O | O | G | O | S | S | O | S | O | S | O | S |
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| S | O | O | S | O | O | O | O | O | O | S | O | O | O | G | O | O | S | O | O | O | M | O | O |
| S | S | S | S | S | O | O | O | S | S | S | O | S | S | G | S | S | O | O | O | O | S | O | O |
| S | S | O | O | S | O | O | O | O | O | S | O | S | O | G | O | S | S | O | S | O | S | O | S |
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| S | O | O | O | S | S | O | O | S | O | S | S | M | O | G | S | O | S | O | O | S | S | O | O |
| S | O | S | S | S | S | S | S | S | S | S | S | O | S | G | S | O | S | O | S | O | S | O | O |
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| S | O | S | O | S | S | O | O | S | O | S | S | M | S | G | S | O | S | O | S | O | O | O | O |

D = Diatom; F = Filamentous fungi; Y = Yeast;

Table 3. Genera and Relative Abundance of Microorganisms on Test Panels After

| Paint Formula | Tin (%) | Achromobacter (B) | Alternaria (F)[b] | Amphisphaeria (F) | Aspergillus (F)[b] | Candida (Y) | Cephalosporium (F) | Chaetomium (F) | Cirrenalia (F) | Cladosporium (F) | Cocconeis (D) | Co[illegible]ospora (F) | Cryptococcus (Y) | Culcitalna (F) | Ectocarpus (A) | Enteromorpha (A) | Flavobacterium (B) | Grammatophora (D) | Helicoma (F) | Leptosphaeria (F) | Lulworthia (F) | Melosira (D) | Metschnikowiella (Y) | Micrococcus (B) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | S | S | O | S | S | S | O | O | O | S | O | M | S | O | O | S | O | S | O | O | O | M | M |
| 1 | 0.0 | M | S | S | S | S | S | O | O | S | O | O | S | O | S | S | S | O | S | O | S | O | M | O |
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| 2 | 1.0 | S | S | S | O | O | O | O | O | O | O | O | S | O | O | O | S | O | O | O | S | O | O | O |
| 3 | 1.8 | S | S | O | S | S | S | O | O | S | O | O | S | O | O | O | M | O | S | O | O | O | M | O |
| 3 | 1.8 | S | S | O | S | S | S | O | O | S | O | S | S | O | O | O | S | O | S | O | S | O | S | O |
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| 4 | 2.3 | S | S | O | S | S | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O | O |
| 5 | 0.9 | S | S | O | S | S | S | O | O | O | O | O | S | O | O | O | M | O | S | O | O | O | M | O |
| 5 | 0.9 | S | S | O | O | S | O | O | O | O | O | O | S | O | O | O | S | O | O | O | S | O | S | O |
| 6 | 1.8 | S | S | O | S | S | S | O | O | S | O | O | S | O | O | O | S | O | S | O | O | O | S | O |
| 6 | 1.8 | S | S | O | O | S | O | O | O | S | O | O | S | O | O | O | S | O | O | O | O | O | S | O |
| 7 | 2.6 | S | O | O | O | S | S | O | O | S | O | O | S | O | O | O | S | O | S | O | S | O | S | O |
| 7 | 2.6 | S | O | O | O | S | S | O | O | O | O | O | O | O | O | O | S | O | O | O | O | O | S | O |
| 8 | 3.1 | S | O | O | O | O | O | O | O | O | O | O | S | O | O | O | S | O | O | O | S | O | S | O |
| 8 | 3.1 | S | O | O | O | S | O | O | O | O | O | O | S | O | O | O | O | O | O | O | S | O | S | O |
| 9 | 6.0 | S | O | O | O | S | O | O | O | O | O | O | O | O | O | O | S | O | O | O | O | O | O | O |
| 9 | 6.0 | S | O | O | O | O | O | O | O | O | O | O | O | O | O | O | S | O | S | O | O | O | S | O |
| 10 | 0.0 | S | S | S | S | M | S | S | S | S | O | O | S | S | S | O | M | O | M | S | S | O | S | M |
| 10 | 0.0 | S | S | O | O | S | O | O | O | O | O | O | S | O | O | O | S | O | O | O | O | O | S | O |

[a]Abbreviations for type and amount of growth: A = Filamentous alga; B = Bacterium; D = Diatom; F = Filamentous fungi; Y = Yeast; G = Abundant growth; M = Moderate growth; S = Sparse; O = No growth.

[b]Non-marine specie present as transient.

nce of Microorganisms on Test Panels After 3 Months[a]

| | Grammatophora (D) | Helicoma (F) | Leptosphaeria (F) | Lulworthia (F) | Melosira (D) | Metschnikowiella (Y) | Micrococcus (B) | Nitzschia (D) | *Penicillium* (F)[b] | Polysiphonia (A) | Pseudomonas (B) | Rhizopus (F)[b] | Rhodotorula (Y) | *Sarcina* (B) | Striatella (D) | Streptomyces (B) | Torpedospora (F) | Torulopsis (Y) | *Trichoderma* (F) | Zaleriom (F) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S | O | S | O | O | O | M | M | O | G | O | G | O | M | S | O | S | O | S | O | S |
| S | O | S | O | S | O | M | O | O | M | O | G | O | S | S | O | S | O | S | O | O |
| S | O | O | O | S | O | S | O | O | S | O | G | S | S | S | O | O | O | S | O | O |
| S | O | O | O | S | O | O | O | O | S | O | G | S | S | O | O | O | O | S | O | O |
| M | O | S | O | O | O | M | O | O | G | O | G | O | S | S | O | O | O | O | O | O |
| S | O | S | O | S | O | S | O | O | G | O | G | O | S | S | O | S | O | S | S | O |
| S | O | O | O | O | O | S | O | O | S | O | G | O | S | O | O | O | O | O | O | O |
| O | O | O | O | O | O | O | O | O | S | O | M | O | O | O | O | O | O | O | O | O |
| M | O | S | O | O | O | M | O | O | G | O | G | O | S | S | O | O | O | O | O | O |
| S | O | O | O | S | O | S | O | O | S | O | M | O | O | S | O | O | O | S | O | O |
| S | O | S | O | O | O | S | O | O | M | O | G | O | S | S | O | O | O | S | O | O |
| S | O | O | O | O | O | S | O | O | M | O | M | O | S | O | O | O | O | S | O | O |
| S | O | S | O | S | O | S | O | O | M | O | G | O | S | S | O | O | O | S | O | O |
| S | O | O | O | O | O | S | O | O | S | O | G | O | S | S | O | O | O | S | O | O |
| S | O | O | O | S | O | S | O | O | S | O | M | O | S | O | O | O | O | O | O | O |
| O | O | O | O | S | O | S | O | O | S | O | M | O | O | O | O | O | O | O | O | O |
| S | O | O | O | O | O | O | O | O | S | O | M | O | O | O | O | O | O | O | O | O |
| S | O | S | O | O | O | S | O | O | S | O | M | O | S | O | O | O | O | O | O | O |
| M | O | M | S | S | O | S | M | O | M | O | G | S | M | S | O | S | O | S | O | S |
| S | O | O | O | O | O | S | O | O | S | O | M | O | S | S | O | O | O | O | O | O |

s fungi; Y = Yeast;

Table 4. Fouling Ratings After 2 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids |
|---|---|---|---|
| 1 | 0.0 | Heavy | Heavy |
| 1 | 0.0 | Heavy | Medium |
| 2 | 1.0 | Light | None |
| 2 | 1.0 | Heavy | Few |
| 3 | 1.8 | Heavy | Few |
| 3 | 1.8 | Light | None |
| 4 | 2.3 | Light | None |
| 4 | 2.3 | Heavy | Medium |
| 5 | 0.9 | Light | Few |
| 5 | 0.9 | Heavy | None |
| 6 | 1.8 | Heavy | None |
| 6 | 1.8 | Heavy | None |
| 7 | 2.6 | Light | None |
| 7 | 2.6 | Heavy | None |
| 8 | 3.1 | Light | None |
| 8 | 3.1 | Light | None |
| 9 | 6.0 | Heavy | None |
| 9 | 6.0 | Medium | None |
| 10[a] | 0.0 | Medium | None |
| 10[a] | 0.0 | Medium | None |

[a]MIL-P-15931 antifouling paint used as standard.

Table 5. Fouling Ratings After 3 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae |
|---|---|---|---|---|---|---|---|
| 1 | 0.0 | Light | Heavy | 10 | Few | Few | Few |
| 1 | 0.0 | Light | Medium | 14 | 0 | None | None |
| 2 | 1.0 | Medium | Few | None | 0 | None | None |
| 2 | 1.0 | Heavy | Few | 4 | 0 | None | None |
| 3 | 1.8 | Heavy | Few | 1 | 0 | None | None |
| 3 | 1.8 | Heavy | Few | 1 | 0 | None | None |
| 4 | 2.3 | Heavy | Few | None | 0 | None | None |
| 4 | 2.3 | Heavy | Few | None | 0 | None | None |
| 5 | 0.9 | Heavy | Few | None | 0 | None | None |
| 5 | 0.9 | Heavy | None | None | 0 | None | None |
| 6 | 1.8 | Heavy | None | None | 0 | None | None |
| 6 | 1.8 | Heavy | None | None | 0 | None | None |
| 7 | 2.6 | Heavy | None | None | 0 | None | None |
| 7 | 2.6 | Heavy | Few | 1 | 0 | None | None |
| 8 | 3.1 | Medium | Few | 2 | 0 | None | None |
| 8 | 3.1 | Medium | None | None | 0 | None | None |
| 9 | 6.0 | Heavy | None | None | 0 | None | None |
| 9 | 6.0 | Heavy | None | None | 0 | None | None |
| 10[a] | 0.0 | Heavy | None | None | 0 | None | None |
| 10[a] | 0.0 | Heavy | None | None | 0 | None | None |

[a] MIL-P-15931 antifouling paint used as standard.

Table 6. Fouling Ratings after 4 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae |
|---|---|---|---|---|---|---|---|
| 1 | 0.0 | Heavy | Heavy | 15 | 32 | Few | Few (green) |
| 1 | 0.0 | Medium | Heavy | 15 | 4 | 0 | 0 |
| 2 | 1.0 | Heavy | Few | 0 | 0 | 0 | 0 |
| 2 | 1.0 | Heavy | Medium | 1 | 0 | 0 | 0 |
| 3 | 1.8 | Heavy | Few | 2 | 0 | 0 | 0 |
| 3 | 1.8 | Medium | Medium | 0 | 0 | 0 | 0 |
| 4 | 2.3 | Medium | Medium | 0 | 0 | 0 | 0 |
| 4 | 2.3 | Heavy | Few | 0 | 0 | 0 | Few (red) |
| 5 | 0.9 | Heavy | 0 | 0 | 0 | 0 | 0 |
| 5 | 0.9 | Heavy | 0 | 0 | 0 | 0 | 0 |
| 6 | 1.8 | Heavy | Few | 0 | 0 | Few | 0 |
| 6 | 1.8 | Heavy | Few | 0 | 0 | 0 | 0 |
| 7 | 2.6 | Heavy | Few | 0 | 0 | 0 | 0 |
| 7 | 2.6 | Heavy | Medium | 0 | 0 | 0 | 0 |
| 8 | 3.1 | Heavy | Medium | 2 | 0 | 0 | Few (red) |
| 8 | 3.1 | Medium | Few | 0 | 0 | 0 | Few (red) |
| 9 | 6.0 | Heavy | 0 | 0 | 0 | 0 | 0 |
| 9 | 6.0 | Heavy | 0 | 0 | 0 | 0 | 0 |
| 10[a] | 0.0 | Medium | 0 | 0 | 0 | 0 | 0 |
| 10[a] | 0.0 | Heavy | 0 | 0 | 0 | 0 | 0 |

[a]MIL-P-15931 antifouling paint used as standard.

Table 7. Fouling Ratings after 5 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | Heavy | Heavy | Heavy[a] | Heavy[a] | Few[a] | Few red, green, brown | Medium |
| 1 | 0.0 | Medium | Heavy | Heavy[a] | Heavy[a] | Few[a] | Few red | Medium |
| 2 | 1.0 | Heavy | Medium | 3 | 0 | 0 | Few red, brown | Few |
| 2 | 1.0 | Heavy | Heavy | 0 | Heavy[a] | 0 | Few red, green, brown | Few |
| 3 | 1.8 | Heavy | Medium | 5 | 4 | 0 | Few red, brown | 0 |
| 3 | 1.8 | Medium | Medium | 0 | 0 | 1 | 0 | 0 |
| 4 | 2.3 | Medium | Medium | 0 | 0 | 0 | 0 | 0 |
| 4 | 2.3 | Heavy | Medium | 0 | 3 | 0 | Few red | 0 |
| 5 | 0.9 | Heavy | Few | 0 | 0 | 0 | Few red | 0 |
| 5 | 0.9 | Heavy | Heavy | 0 | 0 | 0 | Few red | 0 |
| 6 | 1.8 | Heavy | Few | 0 | 2 | 0 | Few brown | 0 |
| 6 | 1.8 | Heavy | Heavy | 0 | 2 | 0 | Few red | 0 |
| 7 | 2.6 | Medium | Few | 0 | 0 | 0 | 0 | 0 |
| 7 | 2.6 | Heavy | Few | 2 | 4 | 0 | 0 | 0 |
| 8 | 3.1 | Heavy | Heavy | 3 | Heavy[a] | 0 | Few red | 0 |
| 8 | 3.1 | Heavy | Few | 0 | Few[a] | 0 | Few red | 0 |

continued

Table 7. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 9 | 6.0 | Heavy | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 6.0 | Heavy | Medium | 0 | 0 | 0 | 0 | 0 |
| 10[b] | 0.0 | Heavy | 0 | 0 | 0 | 0 | 0 | 0 |
| 10[b] | 0.0 | Heavy | 0 | 0 | 0 | 0 | 0 | 0 |

[a] Obscured by heavy hydroid growth.
[b] MIL-P-15931 antifouling paint used as standard.

Table 8. Fouling Ratings After 6 Months[a]

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms | Mussels |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | Heavy | Heavy | Medium | Very Heavy | Heavy | Medium red | Medium | 0 |
| 1 | 0.0 | Heavy | Heavy | Medium | Heavy | Few | Medium red, brown, green | Medium | 0 |
| 2 | 1.0 | Heavy | Medium | 2 | Medium | 1 | Few red, brown, green | 0 | Few |
| 2 | 1.0 | Heavy | Heavy | 2 | Heavy | 2 | Medium red, brown, green | Few | 0 |
| 3 | 1.8 | Heavy | Few | 3 | Few | Few | Few red | 0 | 0 |
| 3 | 1.8 | Heavy | Few | 1 | Few | 1 | Few red, brown | 1 | 0 |
| 4 | 2.3 | Heavy | Medium | 3 | Medium | 0 | Few red | 0 | 0 |
| 4 | 2.3 | Heavy | Few | 0 | Medium | 0 | Medium red | 0 | 0 |
| 5 | 0.9 | Heavy | Few | 0 | 0 | 0 | Few red | 0 | 0 |
| 5 | 0.9 | Heavy | Medium | 0 | Few | Few | Few red | 0 | 1 |
| 6 | 1.8 | Heavy | Few | 0 | Few | 0 | Few red, brown | 0 | 0 |
| 6 | 1.8 | Heavy | Medium | 0 | Few | 0 | Medium red, brown, green | 0 | 0 |
| 7 | 2.6 | Heavy | Few | 1 | 0 | 0 | Few red | 1 | 0 |

continued

Table 8. Continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms | Mussels |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 2.6 | Heavy | Few | Few | Medium | 0 | Medium red | 0 | 0 |
| 8 | 3.1 | Heavy | Heavy | 5 | Heavy | 1 | Medium { red, brown, green | 2 | 0 |
| 8 | 3.1 | Heavy | Heavy | 2 | Medium | 3 | Medium { red, brown, green | 0 | 0 |
| 9 | 6.0 | Medium | 0 | 0 | 0 | 0 | Few { red, brown | 0 | 0 |
| 9 | 6.0 | Heavy | Few | 0 | Few | 0 | Medium red | 0 | 0 |
| 10[b] | 0.0 | Heavy | 0 | 0 | 0 | 0 | Few red | 0 | 0 |
| 10[b] | 0.0 | Medium | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[a]Caprella were observed feeding on the fouling.

[b]MIL-P-15931 antifouling paint used as standard.

Table 9. Fouling Ratings After 7 Months[a]

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms | Mussels |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | Heavy | Heavy | Medium | Very Heavy | Very Heavy | Medium: red, green | Medium | 0 |
| 1 | 0.0 | Heavy | Heavy | Medium | Heavy | Medium | Medium: red, brown, green | Medium | 0 |
| 2 | 1.0 | Heavy | Medium | 4 | Medium | 0 | Medium: red, brown, green | 1 | 1 |
| 2 | 1.0 | Heavy | Heavy | 1 | Heavy | 0 | Medium: red, brown, green | 6 | 0 |
| 3 | 1.8 | Heavy | Medium | 6 | Few | 0 | Few red | 0 | 0 |
| 3 | 1.8 | Heavy | Medium | 1 | Medium | 1 | Few red | 0 | 0 |
| 4 | 2.3 | Heavy | Medium | 3 | Medium | 0 | Few red | 0 | 0 |
| 4 | 2.3 | Heavy | Medium | 1 | Few | 0 | Medium: red, brown | 0 | 0 |
| 5 | 0.9 | Heavy | Few | 0 | Few | 0 | Few red | 0 | 0 |
| 5 | 0.9 | Heavy | Medium | 0 | Few | 0 | Few: red, brown | 0 | 0 |
| 6 | 1.8 | Medium | Few | 1 | Few | 0 | Few: red, brown | 0 | 0 |
| 6 | 1.8 | Heavy | Medium | 0 | Few | 0 | Medium: red, brown, green | 0 | 0 |

continued

Table 9. Continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms | Mussels |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 2.6 | Heavy | Few | 1 | Few | 0 | Few red | 0 | 0 |
| 7 | 2.6 | Heavy | Medium | Medium | Medium | Few | Few {red, brown} | 0 | 0 |
| 8 | 3.1 | Heavy | Heavy | 2 | Heavy | Medium | Medium {red, brown} | 2 | 0 |
| 8 | 3.1 | Heavy | Medium | 2 | Medium | 1 | Medium {red, brown, green} | 0 | 0 |
| 9 | 6.0 | Light | 0 | 0 | 0 | 0 | Few red | 0 | 0 |
| 9 | 6.0 | Heavy | Few | 0 | Few | 0 | Few red | 0 | 0 |
| 10[b] | 0.0 | Medium | Few | 0 | Few | 0 | Few red | 0 | 0 |
| 10[b] | 0.0 | Medium | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[a]Caprellas feeding on fouling.

[b]MIL-P-15931 antifouling paint used as standard.

Table 10. Fouling Ratings after 8 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | | Tube Worms |
|---|---|---|---|---|---|---|---|---|---|
| 1[a] | 0.0 | Heavy | Heavy | Medium | Very Heavy | Heavy | Medium | red, green | Heavy |
| 1 | 0.0 | Heavy | Heavy | Few | Heavy | Heavy | Medium | red, brown, green | Heavy |
| 2[b] | 1.0 | Heavy | Medium | Few | Medium | 2 | Medium | red, brown, green | 1 |
| 2 | 1.0 | Heavy | Heavy | 4 | Heavy | 1 | Medium | red, brown, green | 5 |
| 3 | 1.8 | Heavy | Few | Medium | Few | 0 | Few | red, brown | 0 |
| 3 | 1.8 | Heavy | Medium | Few | Few | 1 | Few | red, brown, green | 0 |
| 4 | 2.3 | Heavy | Few | 3 | Few | 0 | Few | red, brown | 0 |
| 4 | 2.3 | Heavy | Medium | 1 | Few | 0 | Few | red, brown, green | 0 |
| 5 | 0.9 | Heavy | Few | 0 | Few | 0 | Few | red, brown, green | 0 |
| 5 | 0.9 | Heavy | Medium | 0 | Few | 0 | Few | red | 0 |

continued

Table 10. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 6 | 1.8 | Heavy | Few | 2 | Few | 0 | Medium {red, brown, green} | 0 |
| 6 | 1.8 | Heavy | Heavy | 2 | Few | 0 | Medium {red, brown, green} | 0 |
| 7 | 2.6 | Heavy | Few | 2 | Few | 0 | Medium {red, brown, green} | 0 |
| 7 | 2.6 | Heavy | Heavy | Medium | Medium | Few | Medium {red, brown} | 0 |
| 8 | 3.1 | Heavy | Heavy | 6 | Heavy | Medium | Medium {red, brown, green} | 2 |
| 8 | 3.1 | Heavy | Heavy | 7 | Medium | 2 | Medium {red, brown, green} | 0 |
| 9 | 6.0 | Medium | Few | 0 | 0 | 0 | Few red | 0 |
| 9 | 6.0 | Heavy | Medium | 0 | Few | 0 | Few red | 0 |
| 10[c] | 0.0 | Medium | Few | 0 | Few | 0 | Few red | 0 |
| 10[c] | 0.0 | Medium | 0 | 0 | 0 | 0 | Few red | 0 |

[a] A few sponges.
[b] One mussel.
[c] MIL-P-15931 antifouling paint used as standard.

Table 11. Fouling Ratings after 9 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae[a] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 1[b] | 0.0 | Heavy | Heavy | Medium | Very Heavy | Heavy | Medium {red, brown, green} | Heavy |
| 1[c] | 0.0 | Heavy | Heavy | Medium | Heavy | Heavy | Medium {red, brown, green} | Heavy |
| 2[d] | 1.0 | Heavy | Heavy | 9 | Medium | 1 | Medium {red, brown, green} | 1 |
| 2 | 1.0 | Heavy | Heavy | 8 | Medium | 3 | Medium {red, brown, green} | 5 |
| 3 | 1.8 | Heavy | Heavy | 5 | Few | 1 | Few {red, brown, green} | 0 |
| 3 | 1.8 | Heavy | Medium | 7 | Medium | 1 | Medium {red, brown} | 0 |
| 4 | 2.3 | Heavy | Medium | 5 | Medium | 0 | Few {red, brown, green} | 0 |
| 4 | 2.3 | Heavy | Heavy | 1 | Few | 0 | Medium {red, brown, green} | 0 |
| 5 | 0.9 | Heavy | Heavy | 0 | Few | 0 | Medium {red, brown} | 0 |

continued

Table 11. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae[a] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 5 | 0.9 | Heavy | Heavy | 0 | Few | 0 | Medium red, brown, green | 0 |
| 6 | 1.8 | Heavy | Medium | 3 | Few | 0 | Few red, brown | 0 |
| 6 | 1.8 | Heavy | Heavy | 2 | Few | 0 | Few red, brown, green | |
| 7 | 2.6 | Heavy | Few | 2 | Few | 0 | Few red, brown, green | 0 |
| 7 | 2.6 | Heavy | Heavy | 25 | Heavy | 6 | Few red, brown, green | 0 |
| 8 | 3.1 | Heavy | Heavy | 6 | Medium | 7 | Medium red, brown, green | 1 |
| 8 | 3.1 | Heavy | Heavy | 6 | Few | 3 | Medium red, brown, green | 0 |
| 9 | 6.0 | Heavy | Few | 0 | 0 | 0 | Few red, brown | 0 |
| 9 | 6.0 | Heavy | Medium | 0 | 0 | 0 | Few red, brown | 0 |

continued

Table 11. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae[a] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 10[e] | 0.0 | Heavy | Few | 0 | Few | 0 | Few {red, green} | 0 |
| 10[e] | 0.0 | Medium | Few | 0 | 0 | 0 | Few {red, brown} | 0 |

[a] In all cases the red algae predominated over the brown and green.
[b] A few mussels and sponges.
[c] A few sponges.
[d] A few mussels.
[e] MIL-P-15931 (Formula 121/63) copper antifouling paint used as standard.

Table 12. Ratings after 10 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae[a] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 1[b] | 0.0 | Heavy | Heavy | Heavy | Very Heavy | Medium | Medium {red brown green} | Medium |
| 1[b] | 0.0 | Heavy | Heavy | Medium | Heavy | Heavy | Medium {red brown green} | Heavy |
| 2 | 1.0 | Heavy | Heavy | 11 | Medium | 1 | Medium {red brown green} | 3 |
| 2 | 1.0 | Heavy | Heavy | 7 | Heavy | 11 | Medium {red brown green} | 7 |
| 3 | 1.8 | Heavy | Heavy | 16 | Medium | 0 | Medium {red brown green} | 0 |
| 3 | 1.8 | Heavy | Heavy | 9 | Few | 1 | Medium {red brown green} | 0 |
| 4 | 2.3 | Heavy | Heavy | 12 | Few | 0 | Few {red brown green} | 0 |
| 4 | 2.3 | Heavy | Heavy | 4 | Few | 0 | Medium {red brown green} | 0 |
| 5 | 0.9 | Heavy | Medium | 0 | Few | 0 | Medium {red brown green} | 0 |

continued

Table 12. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae[a] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 5 | 0.9 | Heavy | Heavy | 0 | Few | 0 | Medium {red, brown} | 0 |
| 6 | 1.8 | Heavy | Medium | 1 | Few | 0 | Few {red, brown, green} | 1 |
| 6 | 1.8 | Heavy | Heavy | 2 | Few | 0 | Medium {red, brown, green} | 0 |
| 7 | 2.6 | Heavy | Few | 3 | Few | 0 | Few {red, brown, green} | 0 |
| 7 | 2.6 | Heavy | Heavy | 31 | Medium | 5 | Medium {red, brown, green} | 0 |
| 8 | 3.1 | Heavy | Heavy | 15 | Heavy | 13 | Medium {red, brown, green} | 2 |
| 8 | 3.1 | Heavy | Heavy | 11 | Medium | 2 | Medium {red, brown, green} | 0 |
| 9 | 6.0 | Heavy | Few | 0 | 0 | 0 | Few {red, brown} | 0 |
| 9 | 6.0 | Heavy | Medium | 0 | Few | 0 | Few {red, brown} | 0 |

continued

Table 12. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Tunicates | Algae[a] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 10[c] | 0.0 | Medium | Few | 0 | Few | 0 | Few {red, brown, green} | 0 |
| 10[c] | 0.0 | Medium | 0 | 0 | 0 | 0 | Few red | 0 |

[a]In all cases the red algae predominated over the brown and green.
[b]A few mussels and sponges.
[c]MIL-P-15931 (Formula 121/63) copper antifouling paint used as standard.

Table 13. Fouling Ratings after 11 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids[a] | Barnacles | Bryozoa | Tunicates | Algae[b] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 1[c,d] | 0.0 | Heavy | Heavy | Heavy | Very Heavy | Medium | Medium {red, brown, green} | Medium |
| 1[c] | 0.0 | Heavy | Heavy | Medium | Heavy | Heavy | Medium {red, brown, green} | Heavy |
| 2 | 1.0 | Heavy | Heavy | 14 | Medium | 4 | Medium {red, brown, green} | 1 |
| 2[e] | 1.0 | Heavy | Heavy | 11 | Medium | 6 | Medium {red, brown, green} | 10 |
| 3 | 1.8 | Heavy | Heavy | 22 | Medium | 2 | Medium {red, brown, green} | 0 |
| 3 | 1.8 | Heavy | Medium | 6 | Medium | 0 | Medium {red, brown, green} | 0 |
| 4 | 2.3 | Heavy | Heavy | 13 | Medium | 0 | Medium {red, brown, green} | 0 |
| 4[d] | 2.3 | Heavy | Heavy | 4 | Medium | 0 | Medium {red, brown, green} | 0 |
| 5 | 0.9 | Heavy | Heavy | 13 | Few | 0 | Medium {red, brown, green} | 0 |

continued

Table 13. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids[a] | Barnacles | Bryozoa | Tunicates | Algae[b] | | Tube Worms |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.9 | Heavy | Heavy | 5 | Few | 0 | Medium | red<br>brown<br>green | 0 |
| 6 | 1.8 | Heavy | Heavy | 2 | Medium | 0 | Medium | red<br>brown<br>green | 2 |
| 6 | 1.8 | Heavy | Heavy | 7 | Medium | 0 | Medium | red<br>brown<br>green | 0 |
| 7 | 2.6 | Heavy | Medium | 2 | Few | 0 | Medium | red<br>green<br>brown | 0 |
| 7 | 2.6 | Heavy | Heavy | 34 | Heavy | 20 | Medium | red<br>green<br>brown | 0 |
| 8 | 3.1 | Heavy | Heavy | 14 | Heavy | Medium | Medium | red<br>green<br>brown | 4 |
| 8 | 3.1 | Heavy | Heavy | 10 | Heavy | 1 | Medium | red<br>green<br>brown | 0 |
| 9 | 6.0 | Heavy | Heavy | 0 | 0 | 0 | Few | red<br>green<br>brown | 0 |
| 9 | 6.0 | Heavy | Heavy | 0 | 0 | 0 | Few | red<br>green<br>brown | 0 |

continued

Table 13. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids[a] | Barnacles | Bryozoa | Tunicates | Algae[b] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 10[f] | 0.0 | Medium | Few | 0 | 0 | 0 | Few { red, green, brown | 0 |
| 10[f] | 0.0 | Heavy | 0 | 0 | 0 | 0 | Few { red, green, brown | 0 |

[a] Some harvesting of hydroids occurred since the last inspection.
[b] In all cases the red algae predominated over the brown and green algae.
[c] A few sponges.
[d] A few mussels.
[e] One anemone.
[f] MIL-P-15931 (Formula 121/6[e]) copper antifouling paint used as standard.

Table 14. Fouling Ratings after 12 Months

| Paint Formula | Tin (%) | Primary Film | Hydroids[a] | Barnacles | Bryozoa | Tunicates | Algae[b] | | Tube Worms |
|---|---|---|---|---|---|---|---|---|---|
| 1[c] | 0.0 | Heavy | Heavy | Heavy | Heavy | Heavy | Medium | red<br>brown<br>green | Heavy |
| 1[c] | 0.0 | Heavy | Heavy | Heavy | Heavy | 2 | Medium | red<br>brown<br>green | Heavy |
| 2[d] | 1.0 | Heavy | Heavy | 15 | Heavy | 10 | Medium | red<br>brown<br>green | 1 |
| 2[e] | 1.0 | Heavy | Heavy | 14 | Heavy | 0 | Medium | red<br>brown<br>green | 4 |
| 3 | 1.8 | Heavy | Medium | 65 | Medium | 0 | Medium | red<br>brown<br>green | 0 |
| 3 | 1.8 | Heavy | Heavy | 16 | Medium | 3 | Medium | red<br>brown<br>green | 0 |
| 4 | 2.3 | Heavy | Heavy | 14 | Few | 2 | Medium | red<br>brown<br>green | 0 |
| 4[f] | 2.3 | Heavy | Heavy | 11 | Medium | 1 | Medium | red<br>brown<br>green | 0 |
| 5 | 0.9 | Heavy | Medium | 7 | Few | 0 | Medium | red<br>brown<br>green | 0 |

continued

Table 14. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids[a] | Barnacles | Bryozoa | Tunicates | Algae[b] | | Tube Worms |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.9 | Heavy | Medium | 9 | Few | 0 | Medium | red, brown, green | 0 |
| 6 | 1.8 | Heavy | Heavy | 3 | Few | 2 | Medium | red, brown, green | 1 |
| 6 | 1.8 | Heavy | Heavy | 20 | Heavy | 0 | Medium | red, brown, green | 0 |
| 7 | 2.6 | Heavy | Heavy | 14 | Few | 1 | Medium | red, brown, green | 0 |
| 7 | 2.6 | Heavy | Heavy | Heavy | Heavy | Heavy | Medium | red, brown, green | 1 |
| 8 | 3.1 | Heavy | Heavy | Medium | Heavy | Heavy | Medium | red, brown, green | 2 |
| 8 | 3.1 | Heavy | Heavy | 10 | Heavy | 1 | Medium | red, brown, green | 0 |
| 9 | 6.0 | Heavy | Heavy | 0 | Few | 1 | Few | red, brown, green | 0 |
| 9 | 6.0 | Heavy | Few | 0 | Few | 0 | Few | red, brown, green | 0 |

continued

Table 14. continued

| Paint Formula | Tin (%) | Primary Film | Hydroids[a] | Barnacles | Bryozoa | Tunicates | Algae[b] | Tube Worms |
|---|---|---|---|---|---|---|---|---|
| 10[g] | 0.0 | Heavy | Few | 0 | Few | 0 | Few {red, brown, green} | 0 |
| 10[g] | 0.0 | Heavy | Few | 0 | 0 | 0 | Few {red, brown, green} | 0 |

[a] Some harvesting occurred since the last inspection.
[b] In all cases the red algae predominated over the brown and green.
[c] Few mussels and medium sponges.
[d] Two mussels.
[e] One anemone.
[f] One limpet.
[g] MIL-P-15931 (Formula 121/63) copper antifouling paint used as standard.

Table 15. Rating of 10-Month Panels at Panama City

| Paint Formula | Tin (%) | Primary Film | Hydroids | Barnacles | Bryozoa | Algae | | | Tunicates | Sponges | Mussels | Tube Worms | Anemone | Other |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Red | Green | Brown | | | | | | |
| 1 | 0 | Heavy | Light | Heavy | Light | None | Few | None | One | None | None | Few | Few | – |
| 2 | 1.0 | Heavy | Light | Medium Heavy | Light | None | Few | None | One | None | None | Few | None | – |
| 3 | 1.8 | Heavy | Light | Medium | Light | None | Few | None | None | None | None | One | None | – |
| 4 | 2.3 | Heavy | Light | Medium | Light | None | Few | None | None | None | None | One | None | Few Spirobis |
| 5[a] | 0.9 | Heavy | Light | None | None | None | None | None | None | None | None | None | None | – |
| 6 | 1.8 | Heavy | Light | Medium | Light | None | None | None | None | None | None | Few | None | – |
| 7 | 2.6 | Heavy | Light | Heavy | Light | None | Few | None | None | None | None | Few | None | 1 Pectin |
| 8 | 3.1 | Heavy | Light | Heavy | Medium | None | Few | None | None | None | None | Medium | None | Few Spirobis 2 Oysters |
| 9 | 6.0 | Heavy | Light | None | None | None | None | None | None | None | None | None | None | – |
| 10[b] | 0 | Heavy | Light | None | None | None | None | None | None | None | None | None | None | – |

[a]Panel had a black surface discoloration.

[b]Copper-based standard antifouling paint MIL-P-15931 (Formula 121/63).

Table 16. Sixteen-month Rating of 2-foot-square Panels

| Paint Formula | Number of Panels | Figure Reference | Fouling Rating | Type of Fouling |
|---|---|---|---|---|
| 1 | 4 | 9 | Heavy | Barnacles, oysters, tunicates, bryozoa, hydroids, tube worms, very few or no algae |
| 5 | 6 | 10 | Moderate | Barnacles (fewer and smaller than Formula 1), hydroids (more than Formula 1), tube worms, tunicates, bryozoa (fewer than Formula 1); no oysters or algae |
| | 1 | 10 | Light | Similar to other six Formula 5 panels but fewer barnacles |

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